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Special Documentation
Proline Prowirl 200

Natural Gas application package

Table of contents

1 Document information

1.1 Document function

This document is part of the Operating Instructions and serves as a reference for application-specific parameters and notes.

It provides detailed information on:
- Every individual parameter in the operating menu
- Advanced technical specifications
- General principles and application tips

1.2 Using this document

1.2.1 Information on the document structure

For information on the arrangement of the parameters in accordance with the menu structure **Operation** menu, **Setup** menu, **Diagnostics** menu along with a short description, see the Operating Instructions for the device.

For information about the operating philosophy, see the "Operating philosophy" chapter in the device's Operating Instructions

1.3 Symbols used

1.3.1 Symbols for certain types of information

Symbol	Meaning
	Tip Indicates additional information.
	Reference to documentation Refers to the corresponding device documentation.
	Reference to page Refers to the corresponding page number.
	Reference to graphic Refers to the corresponding graphic number and page number.
	Operation via local display Indicates navigation to the parameter via the local display.
	Operation via operating tool Indicates navigation to the parameter via the operating tool.
	Write-protected parameter Indicates a parameter that can be locked against changes by entering a user-specific code.

1.3.2 Symbols in graphics

Symbol	Meaning
1, 2, 3 ...	Item numbers
A, B, C, ...	Views
A-A, B-B, C-C, ...	Sections

1.4 Documentation

This manual is Special Documentation and is not a substitute for the Operating Instructions supplied with the device. Refer to the Operating Instructions and other documentation for detailed information.

The Special Documentation is an integral part of the following Operating Instructions:

1.4.1 Device documentation

All devices are supplied with Brief Operating Instructions. These Brief Operating Instructions are not a substitute for the Operating Instructions pertaining to the device!

Detailed information about the device can be found in the Operating Instructions and the other documentation:
- On the CD-ROM supplied (is not included in the delivery for all device versions).
- Available for all device versions via:
  - Internet: www.endress.com/deviceviewer
  - Smart phone/tablet: *Endress+Hauser Operations App*

The information required to retrieve the documentation can be found on the nameplate of the device .

Technical documentation can also be downloaded from the Download Area of the Endress+Hauser web site: www.endress.com→ Download. However this technical documentation applies to a particular instrument family and is not assigned to a specific device.

W@M Device Viewer

1. Launch the W@M Device Viewer: www.endress.com/deviceviewer
2. Enter the serial number (Ser. no.) of the device: see nameplate .
   ↳ All the associated documentation is displayed.

Endress+Hauser Operations App

The *Endress+Hauser Operations App* is available for Android (Google play) and iOS (App Store).

Via the serial number:

1. Launch the *Endress+Hauser Operations App*.
2. Enter the serial number (Ser. no.) of the device: see nameplate .
   ↳ All the associated documentation is displayed.

Via the 2-D matrix code (QR code):

1. Launch the *Endress+Hauser Operations App*.
2. Scan the 2-D matrix code (QR code) on the nameplate .
   ↳ All the associated documentation is displayed.

1.4.2 Standard documentation

Measuring device	Documentation code		
	HART	FOUNDATION Fieldbus	PROFIBUS PA
Prowirl C 200	BA01152D	BA01215D	BA01220D
Prowirl D 200	BA01153D	BA01216D	BA01221D
Prowirl F 200	BA01154D	BA01217D	BA01222D

Measuring device	Documentation code		
	HART	FOUNDATION Fieldbus	PROFIBUS PA
Prowirl O 200	BA01155D	BA01218D	BA01223D
Prowirl R 200	BA01156D	BA01219D	BA01224D

1.4.3 Content and scope

This Special Documentation contains a description of the additional parameters and technical data that are provided with the **Natural Gas** application package. All the parameters that are not relevant for the **Natural Gas** application package are described in the Operating Instructions.

General information about **natural gas** can be found in the "General principles" section (→ 🖹 13).

2 Product features and availability

2.1 Product features

2.1.1 Natural Gas application package

The **Natural Gas** application package enables users to calculate the chemical properties (gross calorific value, net calorific value) of natural gas. The calculations are based on time-tested standard calculation methods. It is possible to automatically compensate for the effect of pressure and temperature via an external or constant value.

The following measured variables can be output with this application package:
- Mass flow
- Corrected volume flow
- Energy flow

The calculations are based on the following standards:
- Enthalpy calculation:
  - AGA5
  - ISO 6976 (contains GPA 2172)
- Density calculation:
  - AGA Nx19
  - ISO 12213- 2 (contains AGA8-DC92)
  - ISO 12213- 3 (contains SGERG-88, AGA8 Gross Method 1)

2.2 Availability

The **Natural Gas** application package is only available for:
- For Prowirl D, F, R:
  Order code for *"Sensor version"*, option 3 *"Mass flow (integrated temperature measurement)"*
- For Prowirl C, O:
  Order code for *"Sensor version"*, option 6 *"Mass flow, Alloy 718"*

If the **Natural Gas** application package was ordered for the flowmeter ex works, this package is available when the measuring device is delivered to the customer. The function is accessed via the operating interfaces of the measuring device, via the Web server or Endress+Hauser's FieldCare asset management software. No particular measures are required to put the application package into operation.

Ways to check function availability in the measuring device:
Using the serial number:
W@M Device viewer [1) → *Order code for "Application package", option EN "Natural Gas"*

If the application package is not available in the measuring device it can be activated during the life cycle of the device. On most flowmeters it is possible to activate the package without having to upgrade the firmware.

Activation without firmware upgrade is possible with the following firmware versions or higher:
- HART: 01.02.zz
- PROFIBUS DP: 01.01.zz
- FOUNDATION Fieldbus: 01.00.zz

ℹ For all earlier firmware versions, the firmware must be upgraded in order to enable the package.

1) www.endress.com/deviceviewer

2.2.1 Enabling without performing a firmware upgrade

You require a conversion kit from Endress+Hauser to enable the application package without upgrading the firmware. This kit contains a release code which must be entered via the operating menu in order to activate the application package.

Once activated the application package is permanently available in the measuring device.

2.2.2 Enabling by performing a firmware upgrade

If you have a measuring device that requires a firmware upgrade before the function can be activated, please contact your Endress+Hauser service organization.

This function requires service-level access to the device.

Please contact your Endress+Hauser service or sales organization for further information regarding availability and firmware upgrades for existing measuring devices.

3 Commissioning

3.1 Configuring the measuring device

Using the **Medium selection** wizard it is possible to set all the parameters that are needed to configure the measuring device for the application with natural gas.

Perform the following to configure the measuring device:

1. Call up the **Medium selection** wizard .
2. In the **Select medium** parameter (→ 📄 10), select the **Gas** option.
3. In the **Select gas type** parameter (→ 📄 10), select the **Natural gas** option.
4. In the **Fixed process pressure** parameter (→ 📄 10), enter the value of the process pressure present.
   ↳ **NOTE!**

   A value > 0 must be entered.
5. In the **Enthalpy calculation** parameter (→ 📄 11), select one of the following options:
   ↳ AGA5

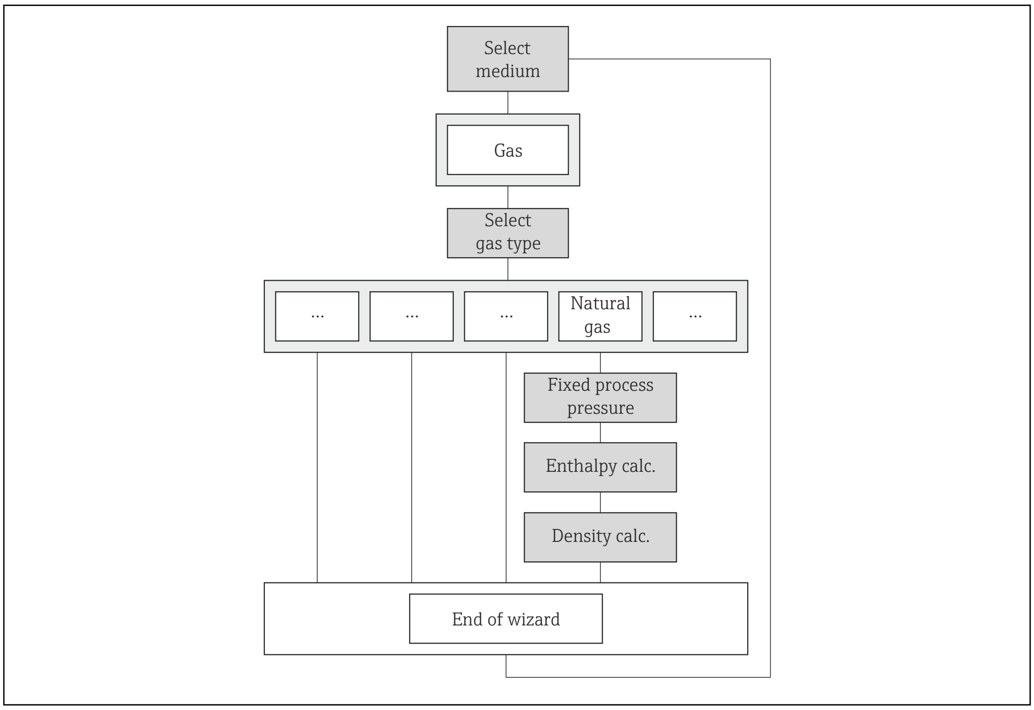
   ISO 6976 option (contains GPA 2172)
6. In the **Density calculation** parameter (→ 📄 11), select one of the following options.
   ↳ AGA Nx19

   ISO 12213- 2 option (contains AGA8-DC92)

   ISO 12213- 3 option (contains SGERG-88, AGA8 Gross Method 1)

Endress+Hauser recommends the use of active pressure compensation. This fully rules out the risk of measured errors due to pressure variations and incorrect entries (→ 📄 12).

Navigation
"Setup" menu → Medium selection



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Parameter overview with brief description

Parameter	Prerequsite	Description	Selection / User entry	Factory setting
Select medium	–	Select medium type.	Gas	Steam
Select gas type	For the following order codes: ▪ *"Sensor version", option "Mass flow"* ▪ *"Application package ", option "Air + Industrial gases" or option "Natural gas"* In the **Select medium** parameter the **Gas** option must be selected.	Select measured gas type.	Natural gas	User-specific gas
Fixed process pressure	–	Enter fixed value for process pressure. *Dependency* The unit is taken from the **Pressure unit** parameter	0 to 250 bar abs.	0 bar abs.

Parameter	Prerequsite	Description	Selection / User entry	Factory setting
Enthalpy calculation	For the following order codes: ▪ *"Sensor version", option "Mass flow (integrated temperature measurement)"* ▪ *"Application package ", option "Natural gas"* In the **Select medium** parameter the **Gas** option must be selected and in the **Select gas type** parameter the **Natural gas** option must be selected.	Select the norm the enthalpy calculation is based on.	▪ AGA5 ▪ ISO 6976	AGA5
Density calculation	If all of the following conditions are met: ▪ In the **Select medium** parameter, the **Gas** option is selected. ▪ In the **Select gas type** parameter, the **Natural gas** option is selected.	Select the norm the density calculation is based on.	▪ AGA Nx19 ▪ ISO 12213- 2 ▪ ISO 12213- 3	AGA Nx19

3.1.1 Activating pressure compensation

Users can choose to also perform active pressure compensation in order to minimize the effect of pressure variations. The pressure can be read in via the current input or fieldbuses.

For detailed information on reading in the pressure, see the Operating Instructions for the device (→ 5)

1. Call up the **External compensation** submenu.
2. In the **External value** parameter (→ 12), select the **Pressure** option.

Navigation

"Setup" menu → Advanced setup → External compensation

External compensation	→	External value
		...
		...

Parameter overview with brief description

Parameter	Description	Selection	Factory setting
External value	Assign variable from external device to process variable.	Pressure	Off

4 General principles

Natural gas plays a very important role in the field of flow measurement. For this reason, users require fundamental knowledge of the units used to measure natural gas and how this measurement is implemented in the Prowirl 200 flow computer.

4.1 Natural gas

Natural gas is a naturally occurring mixture of gaseous hydrocarbons. It consists primarily of methane, but commonly includes longer-chain hydrocarbons, carbon dioxide, nitrogen and hydrogen sulfide. Natural gas is used as a source of energy to heat processes and generate electricity. It is also used as a fuel for vehicles and as a feedstock in the manufacture of plastic and organic chemicals.

Before natural gas can be used as a fuel, it must undergo processing to remove impurities (including water) to meet the specifications of marketable natural gas. The by-products of processing include ethane, propane, butanes, pentanes, and longer-chain hydrocarbons, hydrogen sulfide (which may be converted into sulfur), carbon dioxide, water vapor, and sometimes helium and nitrogen.

“Pipeline-quality” natural gas is composed primarily of methane (molar fraction > 0.7) with a gross calorific value ranging from 30 to 45 MJ/m³. Nitrogen and carbon dioxide reduce the gross calorific value (molar fraction < 0.2 in each case). Ethane, propane, butanes, pentanes and higher alcanes are present in smaller quantities. Traces of helium, benzene and toluene (under 0.01) can also be present. Internationally accepted standards, such as ISO12213, specify acceptable limits for the composition of natural gas.

Examples of the various uses of natural gas

Natural gas-fired power stations generate the bulk of electricity in many countries. The gas is combusted for use in combined heat and power (CHP) systems, gas turbines and steam turbines. The majority of power stations that are brought online to cover peak demand use natural gas. Natural gas burns cleaner than other hydrocarbons, such as oil or coal. Furthermore, the specific carbon dioxide emissions from natural gas are lower. For example, to generate a specific amount of energy natural gas produces 30 % less CO_2 than oil and 45 % less than coal. Combined cycle gas turbines (CCGT) are the cleanest fossil-fired power stations currently available and are becoming increasingly popular given the low price of natural gas.

Other applications include process heating boilers, combustion furnaces and hot water generation.

Compressed natural gas (CNG) is a clean alternative to other vehicle fuels, such as gasoline or diesel.

In the production of fertilizers natural gas is used as a chemical feedstock to produce ammonia using the Haber-Bosch process.

4.1.1 Transportation of natural gas

Because of its low density, it is not easy to transport natural gas by vehicle. New pipelines are being planned or under construction all over the world. LNG carriers transport liquefied natural gas (LNG) by sea while road tankers transport LNG or CNG over shorter distances on land. CNG carriers are currently under development and could provide an alternative to LNG carriers under certain conditions.

Gas is condensed in a liquefaction plant and returned to gas form at the terminal. This process is also performed on the sea carriers. LNG is the preferred form for long distance, high volume transportation of natural gas, whereas pipelines are preferred for land transportation over distances up to 4 000 km (2 485 mi), and for approximately half that distance offshore. CNG is transported at high pressure, typically above 200 bar (2 900 psi). The compressors required are less capital-intensive and can be more economically viable than LNG systems in smaller facilities.

4.1.2 Countries with SI units

Natural gas is sold in gigajoules, cubic meters (m^3) or thousand cubic meters in these countries. When distributing the gas, the volume is almost always measured (cubic meter). In some countries (such as Germany) natural gas is only sold by volume, whereas in other countries it is sold by the energy content (GJ). In these countries, almost all flowmeters in residential or small industrial applications measure the volume in m^3, and the calculations involve a multiplier to convert the volume to energy.

One gigajoule (GJ) is approximately equal to 113.4 kg oil, or 28.3 m^3 gas. The energy content of natural gas can range from 37 to 43 GJ/m^3 depending on the gas composition.

4.1.3 Countries with US units

A standard cubic foot (1 SCF = 28 l) of natural gas produces roughly 1 028 BTU (gross calorific value). If the water formed during the combustion process does not condense, the energy value produced is approx. 10 % lower (net calorific value).

Natural gas is frequently sold in units of **therms** (1 therm = 100 000 BTU). Gas meters measure the volume of gas used. This is converted to energy units by multiplying the volume by the energy content of the gas.

4.1.4 Energy content of natural gas

Natural gas is typically measured in:
- Standard cubic meters (for 0 °C (+32 °F) and 1.01325 bar (14.696 psi))
- Or SCF (for +16 °C (+60 °F) and 1.0156 bar abs. (14.73 psi abs.)

The gross calorific value is typically around 39 MJ (10.8 kWh), but can vary by several percent. This equates to roughly 49 MJ (13.5 kWh) for one kg of natural gas (at a density of 0.8 kg/m^3).

Water is one of the products given off in the combustion process. If the water remains in a gas state, the energy content is indicated as a net calorific value. If the water that is formed condenses completely, the energy content is indicated as a gross calorific value, i.e. all the energy generated by the combustion process is available to heat the process. The flow computer integrated in Prowirl 200 can calculate and output the energy flow based both on the gross calorific value and on the net calorific value (can be configured).

4.2 Engineering units

The Prowirl 200 primarily measures the operating volume flow regardless of whether the medium used is a liquid, gas or steam. Neither the pressure nor the temperature of the medium is factored into the measured operating volume. However, if the medium used is a gas - and more particularly a natural gas - the user is interested in measuring the normal volume or the mass. The measured value should be output in mass units, normal volume units or energy units.

The primary advantage of natural gas is its role as a source of energy. However the energy of natural gas is typically in relation to the normal volume at different normal or standard conditions.

A list of international normal and standard conditions is provided in the table below:

Conditions	Pressure	Temperature
Normal	1.01325 bar (14.696 psi)	0 °C (+32 °F)
Standard	1.01325 bar (14.696 psi)	+15 °C (+59 °F)
Standard	1.01325 bar (14.696 psi)	+15.6 °C (+60 °F)
Standard	1.01008 bar (14.65 psi)	+20 °C (+68 °F)

A normal cubic meter of a gas is the volume corrected to normal or standard conditions as indicated above. The normal volume is therefore the mass of the gas divided by its reference density under the conditions above. Therefore the normal volume is a unit of mass. Here the temperature has the greatest influence when determining the normal volume.

Example

In the United States the standard temperature is typically defined as 60 °F or 70 °F, but not always. If the wrong reference temperature is used, this results in a significant change in the volume at the same mass.

For example a mass flow of 1 000 kg/h of air at 1.01325 bar (14.696 psi) and 0 °C (+32 °F) results in a normal volume flow of 773.4 Nm^3/h (455 SCFM) [2)].

However if the reference temperature under the same conditions is set at +60 °F (+15.6 °C) - the temperature commonly used in the US - the result is a normal volume flow of 836.8 Nm^3/h (481 SCFM), i.e. a deviation of more than 8 %.

In European countries (e.g. Germany, France and Great Britain) Nm^3 at 0 °C (+32 °F) is typically used, whereas other countries, such as the US, refer to Nm^3 at +15 °C (+59 °F) and Sm^3 at +15 °C (+59 °F).

Differences continue to exist with regard to the local reference combustion temperature that is used to calculate the energy content of natural gas (e.g. +25 °C (+77 °F) in Germany and 0 °C (+32 °F) in France).

4.2.1 Nationally accepted reference conditions

In accordance with ISO 12213, the nationally accepted reference conditions for measuring natural gas are as follows:

SI units

Country	T_1 [°C]	T_2 [°C]
Australia	15	15
Belgium	25	0
Denmark	25	0
Germany	25	0
France	0	0
Great Britain	15	15
Ireland	15	15
Italy	25	0
Japan	0	0
Canada	15	15
The Netherlands	25	0
Austria	25	0
Russia	25	0 or 20
USA	15	15
Note 1: The reference pressure is 1.01325 bar abs. in all countries. Note 2: T1 is the reference combustion temperature. Note 3: T2 is the reference temperature for calculating the normal cubic meter.		

2) Nm^3 = m^3 under normal conditions (SCFM = standard cubic feet per minute)

US units

Country	T_1 [°F]	T_2 [°F]
Australia	59	59
Belgium	77	32
Denmark	77	32
Germany	77	32
France	32	32
Great Britain	59	59
Ireland	59	59
Italy	77	32
Japan	32	32
Canada	59	59
The Netherlands	77	32
Austria	77	32
Russia	77	32 or 68
USA	59	59
Note 1: The reference pressure is 14.696 psi abs. in all countries. Note 2: T1 is the reference combustion temperature. Note 3: T2 is the reference temperature for calculating the normal cubic meter.		

NOTICE

There is no internationally accepted standard for reference conditions.
Therefore Prowirl 200 offers a wide range of options to cover the majority of the different versions used worldwide.

- ▶ Always check the standard conditions that apply in your country. For pressure, a reference value for absolute pressure of 1.01325 bar abs. (14.696 psi abs.) or 1.0 bar abs. (14.504 psi abs.) applies worldwide.

abs. = absolute

4.3 Flow computer

Vortex meters are volumetric flowmeters that can also be used as mass flowmeters if other variables are measured or known. Depending on which particular measured variable needs to be calculated, the Prowirl 200 can be configured using the multivariable measurement of volume flow and temperature.

In the Prowirl 200 energy flow is calculated by multiplying by the specific energy of natural gas. The specific energy is given in energy units per normal volume (e.g. in MJ/Nm^3 or kBTU/SCF). If the device is to output the normal volume, mass or energy, the corresponding units must be entered in the human-machine interface (HMI) of the Prowirl.

The electronics of the Prowirl 200 contain a flow computer that can output these units.

It is only possible to output these units with the *order code for "Sensor version", option "Volume flow"* if the pressure, the temperature and the density of the natural gas used are known at the measuring point and do not vary.

With the *order code for "Sensor version", option "Mass flow (integrated temperature measurement)"* the measuring device is able to determine secondary measured variables directly from the measured primary measured variables using the pressure value (entered or external) and/or the temperature (measured or entered). At a constant pressure, or with the pressure provided via the optional current input/HART/PROFIBUS PA, the flow computer can calculate the following measured variables in accordance with internationally accepted standards using the integrated equations of state and tables:

- Volume flow
- Mass flow
- Normal volume flow
- Energy flow

4.4 Equations of state used by Prowirl 200

The compressibility, (relative) density and specific energy content of natural gas are required to calculate and output the normal volume, mass and/or energy. Globally accepted standards for calculating the mass, normal volume and energy are programmed into Prowirl 200 and can be configured by the user. Other parameters are required depending on the equation of state. Some methods require the complete composition of the natural gas, while others simply require a few properties (e.g. gross calorific value, relative density and molar fractions of CO_2, N_2, H_2).

4.4.1 Density and mass flow

Users can select and configure the equations programmed into the Prowirl 200 device for calculating the compressibility, and therefore the density and mass flow, of natural gas. The following standards are programmed into the device:

ISO 12213-2 (contains AGA8-DC92)
- Mol% CH4
- Mol% N2
- Mol% CO2
- Mol% C2H6
- Mol% C3H8
- Mol% H2O
- Mol% H2S
- Mol% H2
- Mol% CO
- Mol% O2
- Mol% i-C4H10
- Mol% n-C4H10
- Mol% i-C5H12
- Mol% n-C5H12
- Mol% n-C6H14
- Mol% n-C7H16
- Mol% n-C8H18
- Mol% n-C9H20
- Mol% n-C10H22
- Mol% He
- Mol% Ar
- Reference temperature
- Reference combustion temperature
- Reference pressure

AGA NX19
- Mol% N2
- Mol% CO2
- Reference temperature
- Relative density
- Calorific value type
- Reference pressure
- Process pressure

ISO 12213-3 (contains SGERG-88 and AGA Gross Method 1)
- Mol% CO_2
- Mol% H_2
- Reference temperature
- Relative density
- Calorific value
- Process pressure

4.4.2 Net calorific value and gross calorific value

Users can select and configure the equations programmed into the Prowirl 200 device for calculating the net calorific value and gross calorific value. The following standards are programmed into the device:

AGA5
- Mol% CH_4
- Mol% N_2
- Mol% CO_2
- Mol% C_2H_6
- Mol% C_3H_8
- Mol% H_2O
- Mol% H_2S
- Mol% H_2
- Mol% CO
- Mol% O_2
- Mol% i-C_4H_{10}
- Mol% n-C_4H_{10}
- Mol% i-C_5H_{12}
- Mol% n-C_5H_{12}
- Mol% n-C_6H_{14}
- Mol% n-C_7H_{16}
- Mol% n-C_8H_{18}
- Mol% n-C_9H_{20}
- Mol% n-$C_{10}H_{22}$
- Mol% He
- Mol% Ar
- Reference temperature
- Reference pressure

ISO 6976 (contains GPA2172)
- Mol% CH_4
- Mol% N_2
- Mol% CO_2
- Mol% C_2H_6
- Mol% C_3H_8
- Mol% H_2O
- Mol% H_2S
- Mol% H_2
- Mol% CO
- Mol% O_2
- Mol% i-C_4H_{10}
- Mol% n-C_4H_{10}
- Mol% i-C_5H_{12}
- Mol% n-C_5H_{12}
- Mol% n-C_6H_{14}
- Mol% n-C_7H_{16}
- Mol% n-C_8H_{18}
- Mol% n-C_9H_{20}
- Mol% n-$C_{10}H_{22}$
- Mol% He

- Mol% Ar
- Reference temperature
- Reference combustion temperature
- Reference pressure